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THESIS

FIELD INFORMATION SUPPORT TOOL

by

Carrick T. Longley

September 2010

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FIELD INFORMATION SUPPORT TOOL

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The Field Information Support Tool (FIST) is a field-based collection system using commercial-off-the-shelf (COTS) smartphones, customized software, and a robust information management backend known as FusionPortal with a deployable sensor fusion system known as FusionView that enables information to flow from the point of capture to an analyst in near real-time regardless of location or physical proximity. FIST is designed to operate in a variety of environments and supports a variety of mission sets such as counterinsurgency operations (COIN), counter-narcotic missions (CN), and humanitarian assistance and disaster response (HA/DR). The overarching principle of FIST is the development of a user-friendly data collection tool that utilizes automated information systems to enable unstructured data to be collected, processed, and structured for analysis and visualization in a variety of analytic packages. FusionView enables real-time integration of disparate sensor systems that provides a powerful common operating picture critical for today's decision makers. FusionPortal allows for data to be exported and analyzed using geospatial, geo-statistical, link, and social network analysis in addition to enabling the exchange of information with external databases such as the Worldwide Civil Information Database (WCID), the International Studies of Violent Groups (ISVG), and the Combined Information Data Network Exchange (CIDNE).

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LIST OF ACRONYMS AND ABBREVIATIONS

AE	All Environment
AOR	Area of Responsibility
APAN	All Partners Area Network
A-GPS	Assisted Global Positioning System
AV	AeroVironment
CA	Civil Affairs
CARAT	Combined Operations Afloat Readiness and Training
CIDNE	Combined Information Data Network Exchange
CN	Counter Narcotics
COE	Center of Excellence
COI	Communities of Interest
COIN	Counter Insurgency Operations
CONOP	Concept of Operations
COP	Common Operating Picture
CORE	Common Operational Research Environment
COT	Cursor on Target
COTS	Commercial off the Shelf
CP	Counter Proliferation of weapons of mass destruction
CRADA	Cooperative Research and Development Agreement
CT	Counterterrorism
DA	Direct Action
DARPA	Defense Advanced Research Projects Agency
EDR	Enhanced Data Rate
EI	Ethnographic Intelligence
FID	Foreign Internal Defense
FIST	Field Information Support Tool
GATER	Geospatial Assessment Tool for Engineering Reachback
GOTS	Government off the Shelf
GPRS	General Packet Radio Service
GSM	Global System for Mobile communication

HA/DR	Humanitarian Assistance / Disaster Response
HN	Host Nation
iRAPIDS	Interactive Real-time Automated Position Identification System
ISVG	Institute for the Study of Violent Groups
KML	Keyhole Markup Language
KTG	Kestrel Technology Group
MCIP	Multi-national Communications Interoperability Program
NPS	Naval Postgraduate School
ODA	Operational Detachment Alpha
ODK	Open Data Kit
OS	Operating System
PACOM	Pacific Command
POI	Periods of Instruction
PYSOP	Psychological Operations
RDMS	Rapid Data Management System
RF	Radio Frequency
RTN	Royal Thai Navy
SCD	Socio-Cultural Dynamics
SFA	Security Force Assistance
SOCPAC	Special Operations Command Pacific
SIM	Subscriber Identity Module
SNA	Social Network Analysis
SR	Special Reconnaissance
SSL	Secure Socket Layer
TCAPF	Tactical Conflict Assessment Planning Framework
TIGR	Tactical Ground Reporting System
TOC	Tactical Operations Center
TTPs	Tactics, Techniques, and Procedures
U.S.	United States
USAID	United States Agency for International Development
USASOC	United States Army Special Operations Command
USACE	United States Army Corps of Engineers

USB	Universal Serial Bus
UW	Unconventional Warfare
VPN	Virtual Private Network
VSAT	Very Small Aperture Terminal
WCDMA	Wide Code Division Multiple Access
WCID	Worldwide Civil Information Database
WLAN	Wireless Local Area Networking
XML	Extensible Markup Language

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I would like to take this opportunity to thank the great many individuals who have contributed to this endeavor with much hard work and dedication. First and foremost, I want to thank my wife and children for their love and support through the last 24 months. Thank you for understanding the long times away from Monterey I have spent in the development of this project. Without your support, none of this would have been possible. Secondly, I would like to thank Mr. Jim Ehlert for his dedication and belief in this project and the countless hours he has put into this effort—both on work and on leave. It truly has been an honor working with you and I look forward to continuing our partnership in the future. I would like to thank both Dr. Nancy Roberts and Dr. Sean Everton of the CORE lab for their untiring support of FIST. Without your support we would not be where we are today. I would like to give a special thank you to CW3 Chad Machiela, whose support, guidance, and friendship were instrumental in taking FIST from a PowerPoint concept to a project in development. Last, but certainly not least, I would like to thank Mr. Ivan Cardenas and Kestrel Technology Group for their significant and meaningful contributions to seeing this project come to fruition.

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I. INTRODUCTION

A. PROJECT OVERVIEW

The Field Information Support Tool (FIST) is a field data-collection system using commercial-off-the-shelf (COTS) smartphones, customized software, and a robust information management backend known as *FusionPortal* with a deployable sensor fusion system known as *FusionView* that enables information to flow from the point of capture to an analyst in near real-time regardless of location or physical proximity. FIST is designed to operate in a variety of environments and supports a variety of mission sets such as counterinsurgency operations (COIN), counter-narcotic missions (CN), and humanitarian assistance and disaster response (HA/DR). The overarching principle of FIST is the development of a user-friendly data collection tool (*Collect*) that utilizes automated information systems to enable unstructured data to be collected, processed, and structured for analysis and visualization in a variety of analytic packages. *FusionView* enables real-time integration of disparate sensor systems that provides a powerful common operating picture critical for today's decision makers. *FusionPortal* allows for data to be exported and analyzed using geospatial, geo-statistical, temporal, link, and social network analysis in addition to enabling the exchange of information with external databases such as the Worldwide Civil Information Database (WCID), the International Studies of Violent Groups (ISVG), and the Combined Information Data Network Exchange (CIDNE).

FIST was initially conceived as a project focused on integrating cellular technology into tactical radio frequency (RF) networks, but was quickly morphed into a robust collection system focusing primarily on the capture and analysis of socio-cultural dynamics (SCD) information based on the significant capability gap the Department of Defense (DoD) experiences on collecting, processing, and analyzing the "human terrain" of a particular area. SCD and its subsequent analysis provides key decision makers unique insights into the composition, disposition, and strength of a population and the nuisances associated with their wants and desires. In other words, the understanding of

SCD and how it can impact decisions—from tactical to strategic—and its importance to mission accomplishment cannot be overstated. Nevertheless, the DoD lacks a significant capability to collect, process, and analyze information and FIST seeks to provide a much-needed technological advancement in this area.

While SCD continues to remain a focus of the FIST project, there have been equally strong indicators of the system's utility with regards to capturing a myriad of other data to include an overwhelming interest in the collection of information pertaining to natural disasters and humanitarian assistance needs. As such, the scope of FIST has expanded to incorporate data collection for Civil Affairs teams, humanitarian assistance efforts, and disaster response coordination, in addition to its powerful SCD collection capabilities.

FIST uses a flexible and dynamic framework for capturing media-rich reports in the field, structures the information for analysis and distribution via *FusionPortal*, and provides real-time visualization via *FusionView*. FIST harnesses the latest in technological advancements in communications technology, Web-based information management and sharing, and automated decision-aids, while providing real-time alerts critical for decision making in high operating tempo environments. FIST offers advances in the collection, processing, and sharing of information. Its development and subsequent employment will help shape future concepts of operation and improvements for current tactics, techniques, and procedures (TTPs).

The decision to adopt (COTS) technology and use a rapid prototyping process has enabled the FIST team to more quickly move from a concept to a product in the field. The time saved by using COTS greatly reduces the currently arduous military procurement process that lags far behind rapidly advancing technology.

B. SYSTEM DESCRIPTION

1. System Components

FIST is divided into three separate components that comprise the system. The field collection tool is known simply as *Collect*, the Web-based information management portal is known as *FusionPortal*, and the sensor fusion and visualization system is known as *FusionView*. Each component is discussed in further detail in the following sections.

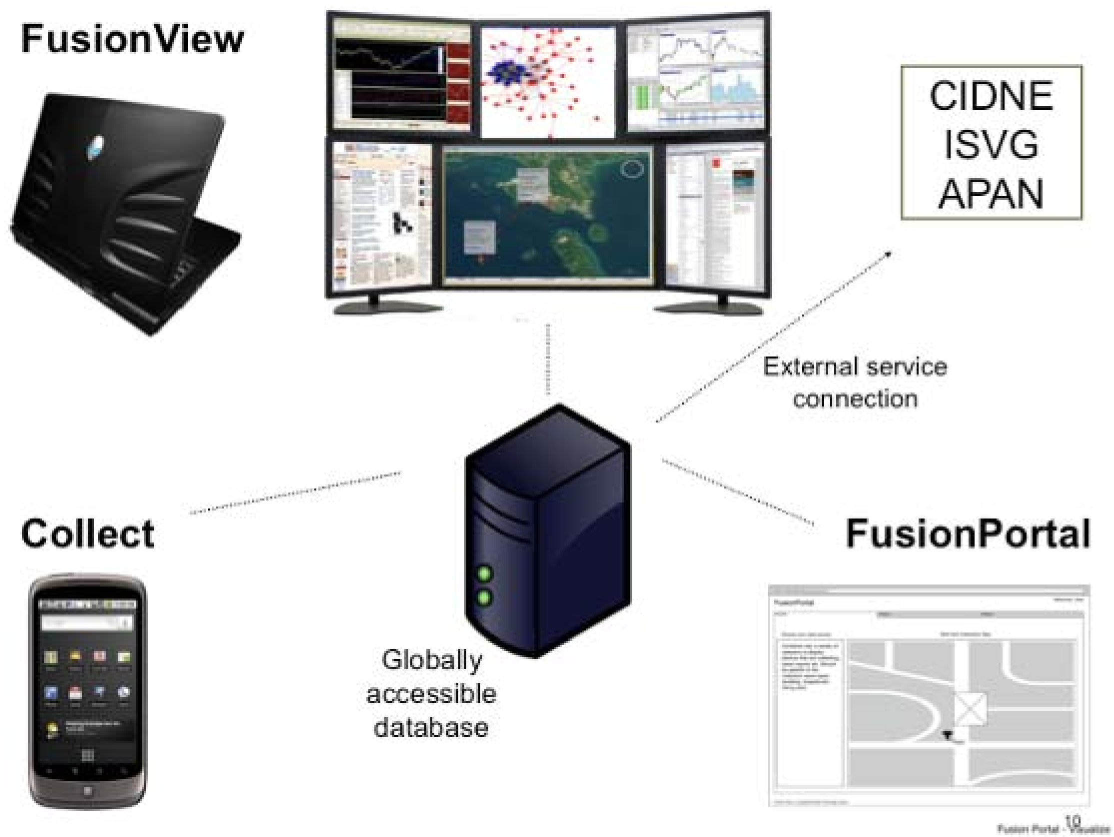

Figure 1. Diagram of FIST components

2. Collect

FIST *Collect* is an Android-based application that enables the collection of data in a structured, form-based menu interface to be transferred to the remote *FusionPortal* server. *Collect* is composed of the smartphone, the mobile operating system, the software application running on the phone, and the collection modules for the specific mission type. The following sections describe the various subcomponents for each category.

a. Smartphone Hardware Specifications

Smartphones today carry an enormous amount of computing and communications power, and it is this strength and flexibility that *Collect* harnesses to allow data to be quickly and rapidly transmitted to *FusionPortal* and the analysts who can be remotely located. The phones all contain a variety of sensors to include global positioning system (GPS) chips, cameras capable of still and video image capture, microphones for audio recording, and internal memory for data storage. These specifications will vary depending on the device, but for all intents and purposes their differences are negligible. For the purposes of this document, only the communications capabilities of the Motorola Milestone (the device selected for the first generation of FIST testing) are described.

The Motorola Milestone is the Global System for Mobile Communication (GSM) version of the popular Motorola Droid, a Code Division Multiple Access (CDMA)-based Android phone released in November 2009 by Verizon Wireless. The Milestone uses voice and data communications in the Wide CDMA (WCDMA) bands (900, 2100 MHz), the GSM bands of (850, 900, 1800, 1900 MHz), and the High Speed Packet Access (HSPA) and General Packet Radio Service (GPRS) Class 12 frequencies (Motorola, 2010).

While the communications capabilities of the Milestone are impressive, it is important to keep in mind that operators are often working in areas with limited or no communications connectivity through terrestrial networks. Furthermore, cellular coverage is not ubiquitous and often only exists in heavily populated urban environments. Additionally, natural disasters can wreak havoc on even robust communications systems, as was the case in Haiti. The recent earthquake destroyed or disabled nearly 100% of the cellular networks and Wi-Fi hotspots were almost non-existent due to the landline network being severely disrupted. In these cases, the only communications path to the outside world is via solutions such as the Broadband Global Access Network (BGAN) terminals or Very Small Aperture Terminals (VSAT)— both satellite communications systems. While satellite communications capabilities do not exist in the Milestone, a configuration of a satellite terminal with an 802.11 access point can provide the necessary connectivity for sending data from the field.

With these uncertainties and limitations in mind, *Collect* was designed with “store and forward” as the foundation of data collection. When network bandwidth is reduced or stopped (in the case of no coverage), reports are locally cached and stored in the “outbox” awaiting network connectivity. Once connectivity has been re-established or network bandwidth has reached an acceptable level, reports are forwarded on to the appropriate backend.

b. Mobile Operating System

There are a number of mobile operating system (OS) platforms in use that account for varying degrees of market share around the world. These operating systems include, but are not limited to: Microsoft Windows Mobile, Symbian OS, Research In Motion Blackberry OS, Apple iPhone OS, and the Android OS. After analyzing the capabilities and limitations of the various operating systems, Google’s Android OS has been down-selected for development of the *Collect* software. The Android OS allows for dynamic, flexible software to be rapidly developed and tested and is currently deployed on a significant number of handsets from the following manufacturers: Acer, Alcatel, Asus, Dell, Garmin, Haier, HTC, Huawei, Kyocera, Lenovo, LG, Motorola, NEC, Samsung, Sharp, Sony Ericsson, Toshiba, and ZTE (Open Handset Alliance, 2010). Additionally, Android enables software to be installed on handsets without requiring approval from Google—a significant departure from the familiar approval process Apple, Inc. employs on their popular iPhone.

Google released their popular Java-based Android Operating System in late 2007. Android has gained tremendous growth in recent months and, as of March 2010, accounts for nearly 46% of the U.S. smartphone market share (Calouro, 2010). The look and feel of the Android OS is similar to that of the iPhone OS, but it provides a much greater degree of flexibility and control over the appearance and behavior of the phone. Android was chosen due to its ability to run host background applications, limited constraints for approval of application deployment, and the use of the Java programming language.

FIST currently has a prototype system developed using Android that is known as *FIST Light*, which allows for customized data collection forms to be created, processed, and visualized in geo-spatial application such as ArcGIS or Google Earth. *FIST Light* is described in greater detail in a subsequent chapter.

c. Handheld Software

The *Collect* handheld software contains a number of capabilities and features that allow for a dynamic, flexible approach to field-based data collection. The primary focus of the application is to allow customized forms to be created and loaded into the device, which support a variety of data types, multimedia formats, and intelligent autosuggestions for commonly used words and names. The software can be broken into three major components: the forms processor, local database, and server interaction functionality. The following paragraphs will discuss each of these components in greater detail.

Since the primary focus of FIST is capturing field data in a structured yet flexible manner, *Collect* is first and foremost a form-based processing engine. Forms are loaded via a network connection to *FusionPortal*, the forms manager, and can be updated in real-time at any future point. The forms support multiple language packs and will render the questions in the appropriate target language, provide a dynamic environment for data validation and streamlined entry, and enable the operator to capture any number of multimedia formats for attachment to the collection report—geo-coordinates, voice, video, and photographs. Although not implemented in the original FIST specification, the ability to attach external Bluetooth devices such as a fingerprint scanner is being considered for future iterations. The local database on the phone provides the ability to cache the collection reports while awaiting transmittal, as well storing collection reports previously submitted to *FusionPortal*. This construct allows for *Collect* to work in an entirely disconnected state while still providing the collector an information rich environment in which to operate. The *Collect—FusionPortal* interaction allows for the transferring of information to and from the smartphones, the updating of forms and collection reports, and access control based on account specifications at the organization's account in *FusionPortal*.

d. Data Collection Modules

As previously discussed, FIST was initially developed for the collection and analysis of socio-cultural dynamics information (SCD). As such, three specific modules were used or developed to collect this information. These modules are the socio-cultural dynamics (SCD) module, Civil Affairs (CA) module, and the Tactical Conflict and Assessment Planning Framework (TCAPF). These three modules enable a user to collect information on three key areas: people's identities; their relationships; and the physical environment, the infrastructure, and the TCAPF. While only three modules were developed for collecting SCD, incorporation of other modules such as law enforcement, psychological operations, humanitarian assistance, disaster relief and operational preparation of an environment are straightforward extensions of the three modules and can be incorporated as necessary.

(1) Socio-cultural Dynamics. The purpose of the SCD module is to capture relevant relational data in the field via an interview process with a primary source (e.g., the individual) or via a secondary source (e.g., police chief, relative). The module uses an anthropological methodology for data collection that was developed at the Naval Postgraduate School by Dr. Nancy Roberts and Chief Warrant Officer Chad Machiela. While socio-cultural dynamics collects attribute information (name, age, sex, occupation, etc), the primary purpose and focus of the module is on the collection of relationship information. By focusing on how individuals are related, predictive and behavioral analysis can be conducted on the data set. In order to capture this information, the SCD module heavily modified a widely used civilian engagement form to incorporate more focus on relational information. The data that are collected from the SCD module can be interpreted and analyzed in a variety of applications allowing both the analyst and the commander alternative means to visualize the data. By looking at the data set

geospatially, temporally, and socially, the data collected are much more useful than traditional attribute-only data. When combined with all-source intelligence products, the data can provide a more robust product that gives the commander a better understanding of who lives in his given area of operation and how they are related.

(2) Civil Affairs. The Civil Affairs forms that can be incorporated in the FIST application are taken directly from the U.S. Army Corp of Engineers (USACE) Geospatial Assessment Tool for Engineering Reachback (GATER) modules. While the data collected by the GATER toolset is primarily used for visualization (ArcGIS and GIS online capabilities), incorporating this capability into a smaller handheld device provides the ability to conduct infrastructure assessments using the same standardized data-collection processes by any tactical operator. Additionally, the information is capable of populating the existing databases that are fielded by these units so as not to replace, but rather augment existing capabilities.

(3) Tactical Conflict Assessment and Planning Framework (TCAPF). TCAPF was developed by the U.S. Agency for International Development (USAID) as a means of helping commanders determine the needs of a population within a specific area of operation. This simple four-part questionnaire is the de facto inter/intra agency tool for collecting population-centric information. FIST has taken what is currently being employed in Afghanistan in an Excel spreadsheet and has incorporated it into a dynamic, menu-driven interview process on the *Collect* application.

3. FusionView

In collaboration with Kestrel Technology Group (KTG) through a Creative Research and Development Agreement (CRADA) with the Naval Postgraduate School (NPS), the former Interactive Real-time Automated Positioning and Identification System (iRAPIDS) system has been renamed, reconfigured and enhanced into a robust field deployable sensor fusion appliance known as *FusionView*. Originally designed as a sensor fusion and aggregation system, *FusionView* has been enhanced to handle field collection reports from *Collect* (via *FusionPortal*) and provide a more robust visualization of the collection reports in a ruggedized field deployable setup.

Additionally, *FusionView* has improved its common operating picture for report visualization, asset tracking and dynamic report updating, and real time alerts and alarms.

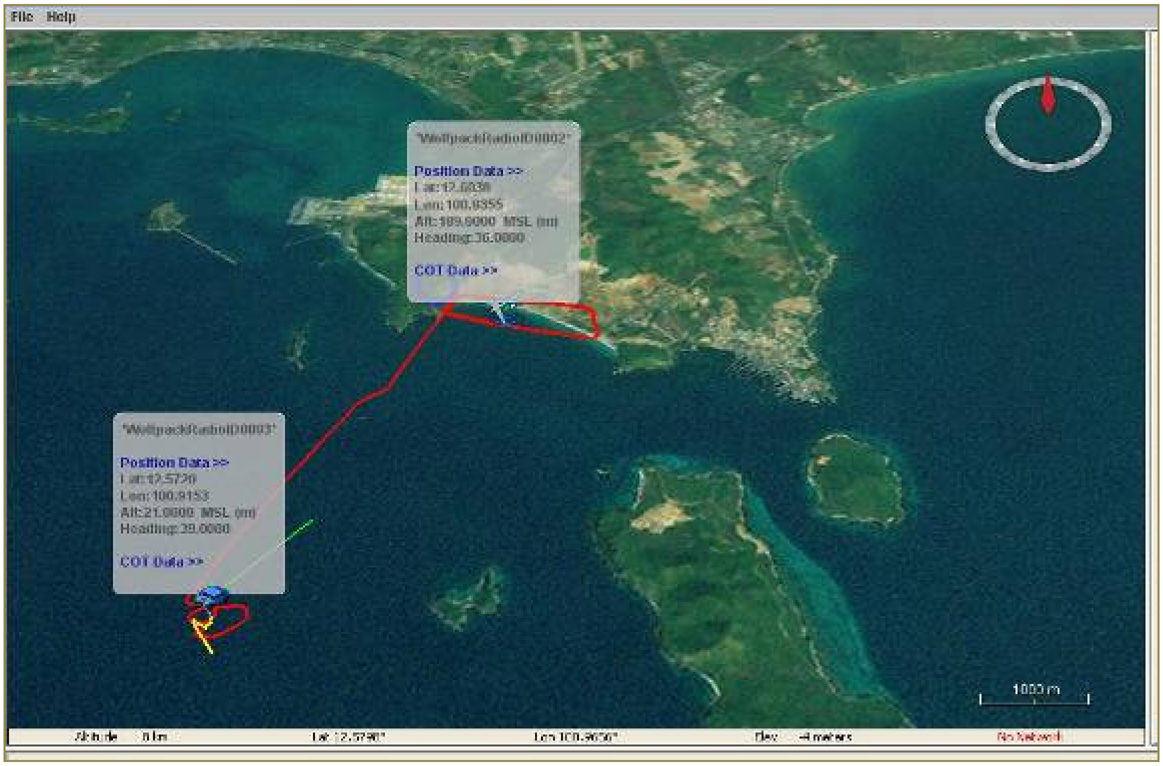

Figure 2. *FusionView* screenshot showing UAV tracks

FusionView is an information, sensor and machine visualization, fusion, analysis and control system with ubiquitous input processing capability. *FusionView* offers an efficient and effective method of:

- Achieving disparate information and hardware integration into a common platform efficiently.
- Dissemination of the visualized information through the vertical chain of command on platforms of choice (laptops, handhelds, network clusters).
- Providing a modeling environment to interface algorithmic operations, such as decision making and pattern recognition, into the visualization and control space.

- Achieving interaction with globally dispersed enterprise level information sources such as in agencies and strategic command centers.

In addition to rich visualization and sensor flexibility, another distinguishing capability of *FusionView* is the incorporation of both Department of Defense and open industry standards for information aggregation and integration formats in a singular Java container.

This total system results in a capable and practical application—one that is multifunctional, real-time, and secure yet structured similarly at all levels, from forward deployed to central command locations. The component architecture natively addresses system-to-system interoperability, so growth and diversity over time is inherently more linear in cost and also easier to add new systems, such as unmanned vehicles, sensors and sensor subsystems, algorithmic systems and models and data interchange with a plurality of sources.

4. FusionPortal

FusionPortal was designed by KTG for the next step in information management and data fusion by adopting the latest in Web service and cloud-computing technologies. Using a streamlined user interface, *FusionPortal* provides visualization, analysis, sharing and device-management functionality for FIST. These four main components of *FusionPortal* form the foundation of the information management component for the enterprise system. As FIST is designed to improve analytic processes, *FusionPortal* supports a number of commercially available software packages for enhancing and improving the analysis of collected data.

a. Commercial Software Integration

(1) UCINET. UCINET is a comprehensive package for the analysis of social network data as well as other 1-mode and 2-mode data (Borgatti, 2010). The application can read and write a multitude of differently formatted text files, as well as Excel files. It has the capacity to handle a maximum of 32,767 nodes (with some exceptions) (source: UCINET help) although practically speaking 5,000–10,000 nodes is

a usable limit with typical data sets. UCINET is the best known and most widely used social network analysis software, and it contains a large number of social network analysis metrics and data management tools. It contains most of the routines needed for estimating measures of network topography (e.g., density, clustering, transitivity), calculating actor centrality (e.g., degree, betweenness, closeness, eigenvector) identifying subgroups (e.g., cliques, components, factions) and estimating various measures of structural equivalence (e.g., structural, auto-morphic, regular), as well as tools for selecting subsets of files, merging and stacking data sets, transposing and/or recoding data, and the importing and exporting of data in a variety of formats. UCINET is an instrumental software package for conducting social network analysis and is the primary software package used in the Common Operational Research Environment (CORE) Lab at the Naval Postgraduate School for social network analysis (SNA). UCINET is the de facto standard for social network analysis packages and it is considered to be the best of breed for its capabilities.

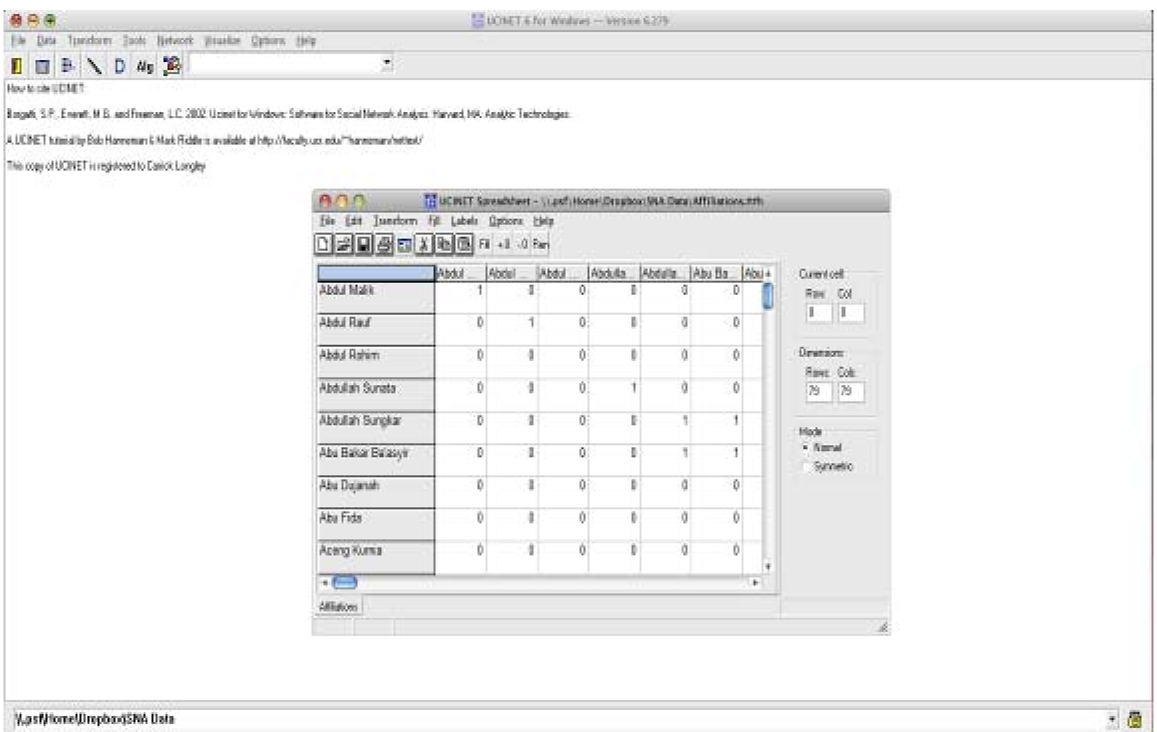

Figure 3. UCINET screen shot

(2) Pajek. Pajek is a social network analysis program designed for handling extremely large datasets (Batagelj & Mrvar, 2010). Pajek works in tandem with a number of freeware programs for analyzing and visualizing networks, and it is capable of importing and exporting data to other popular social network analysis tools such as UCINET. Pajek contains a number of social network analysis metrics not presently found or implemented in UCINET and serves as a complimentary package for in depth social network analysis investigations.

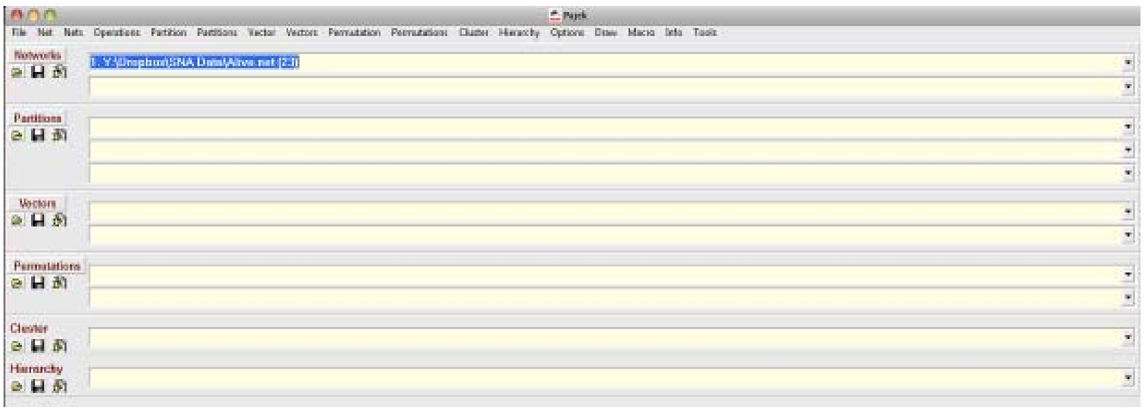

Figure 4. Pajek screen shot

(3) ORA. ORA is a dynamic meta-network assessment and analysis tool developed by CASOS at Carnegie Mellon. According to the developer's Web site (Carley, 2010):

> It [ORA] contains hundreds of social network, dynamic network metrics, trail metrics, procedures for grouping nodes, identifying local patterns, comparing and contrasting networks, groups, and individuals from a dynamic meta-network perspective. *ORA has been used to examine how networks change through space and time, contains procedures for moving back and forth between trail data (e.g. who was where when) and network data (who is connected to whom, who is connected to where …), and has a variety of geo-spatial network metrics, and change detection techniques. *ORA can handle multi-mode, multi-plex, multi-level networks. It can identify key players, groups and vulnerabilities, model network changes over time, and perform COA analysis. It has been tested with large networks (106 nodes per 5 entity classes). Distance based, algorithmic, and statistical procedures for comparing and contrasting networks are part of this toolkit.

ORA is quickly becoming a more widely adopted network analysis tool because of its ability to quickly and accurately distill complicated social network analysis metrics into readable, understandable language. By implementing a familiar user interface and its ability to manipulate a number of different data formats, ORA is an extremely powerful package for conducting social network analysis.

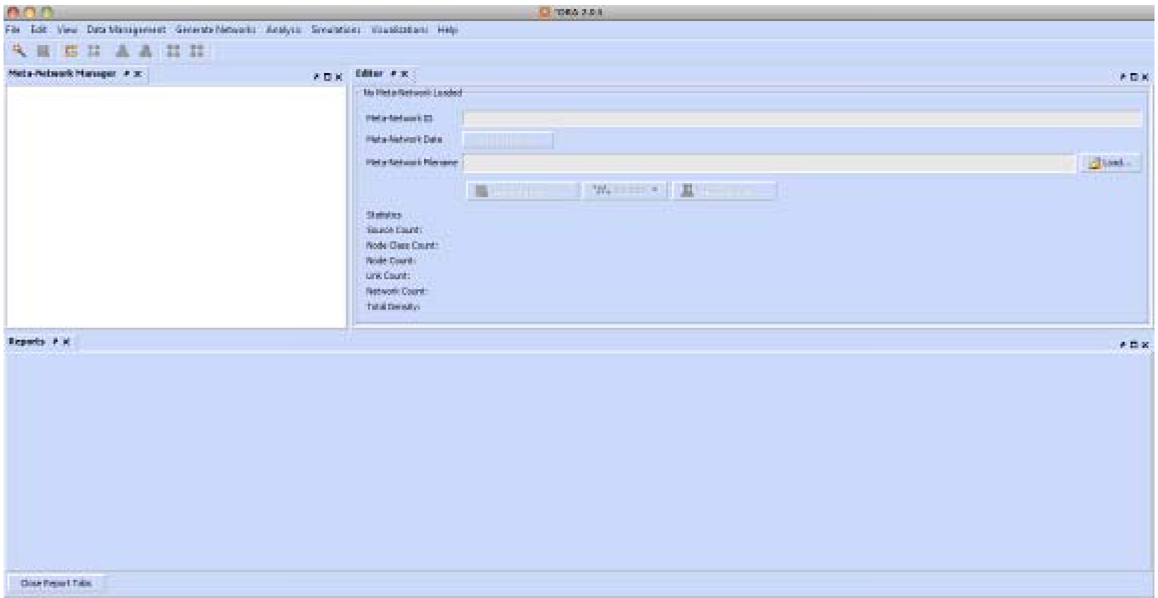

Figure 5. ORA screen shot

(4) ArcInfo. ArcInfo, a graphical information system application from ESRI, is arguably the most prolific GIS software application in use in the DoD. ArcInfo is designed for conducting geospatial analysis and it has support for a wide variety of imagery formats and file formats. ArcInfo includes all the functionality of ArcEditor and ArcView and adds advanced spatial analysis, extensive data manipulation, and high-end cartography tools. ArcInfo is used daily in the DoD to create, edit, and analyze data in order to make better decisions, faster. ArcInfo is the de facto standard for GIS, and ArcInfo provides FIST with a powerful geospatial analysis capability and the software is widely employed throughout the DoD (ESRI, 2010).

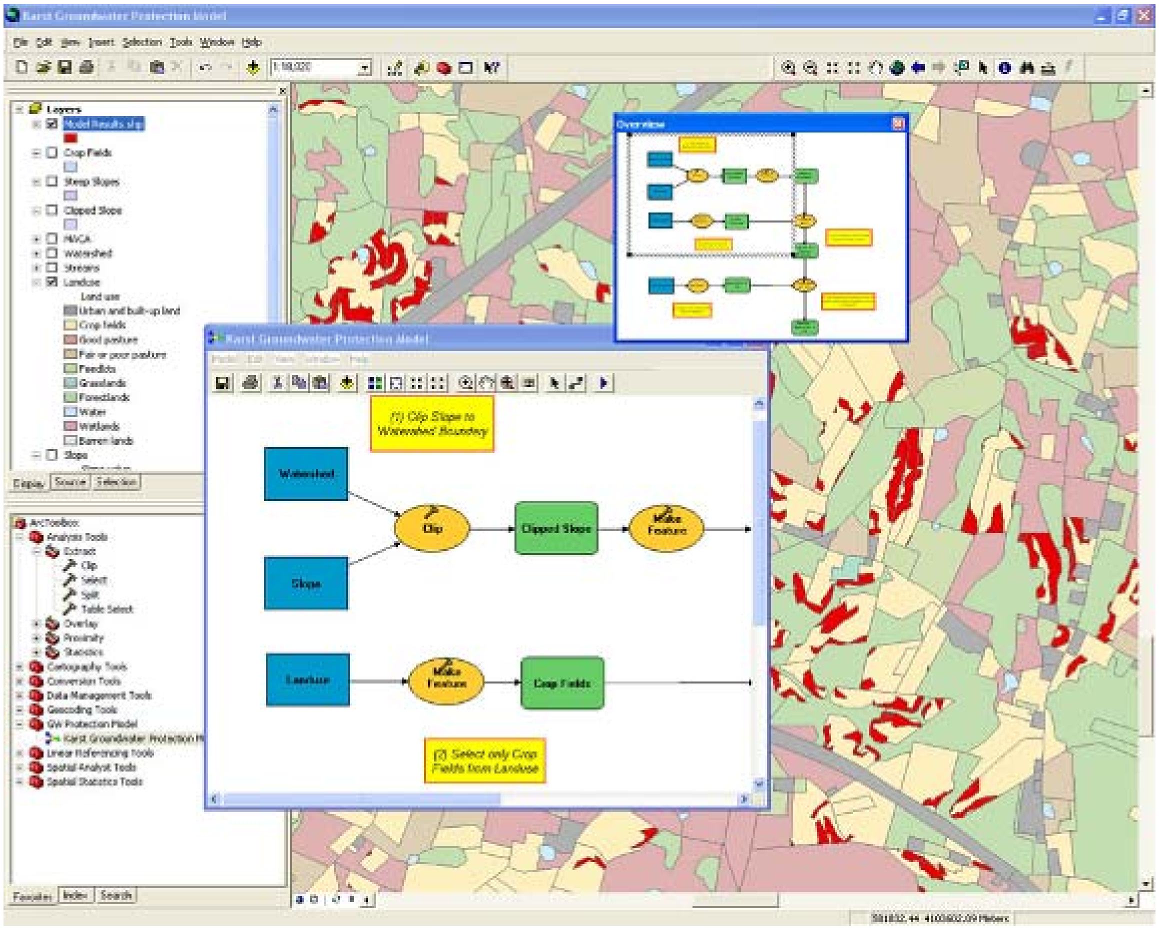

Figure 6. ArcInfo screen shot. From (ESRI, 2010)

C. THE NEED FOR IMPROVED DATA COLLECTION AND ANALYSIS CAPABILITIES

The design of FIST is based on results from operator feedback, a detailed market survey determining the best of government and commercial off the shelf technology, and operational experience conducting data collection in the field both in the Middle East and throughout Asia. Currently, there is a limited technical capability to conduct flexible, dynamic data collection amongst the operating forces. Data that are collected are often stove-piped into antiquated systems, which were either not designed for the particular use or are not flexible enough to meet the changing needs of the operating environment. FIST was architected to solve several of these shortcomings highlighted above.

1. Operator Feedback and Experiences

FIST was developed to minimize operator-training time, automate data formatting, transmittal and structuring, reduce data entry time, and allow for changes to the collection process to be entered from the field. Additionally, a human factors approach to design was adopted such that the menus, prompts, and user interfaces are both efficient and intuitive and allow for the "guess work" to be taken out of conducting collection operations. By following a series of prompts and structured questions, the operator can simply follow through the menus and be guided in the collection process. As a by-product of this structured process, the operator becomes trained in the process of collecting information and not solely on the operation of a single piece of equipment.

Analysts are often forced to use a number of different software packages across multiple levels of security classifications to analyze the information collected. Additionally, analysts have to format information appropriately for each software package used and the process often requires a significant amount of data manipulation. With FIST, data entry and formatting is handled by the system so analysis can be more efficient. Furthermore, every effort has been taken to ensure that data collected by the FIST handheld can be used in a variety of existing analytical software packages to include ArcGIS, Google Earth, Pajek, and UCINET, to name a few. More information regarding the specific implementation of this data exchange is detailed in the system specification.

One of the driving factors behind the development of FIST was the need to equip as many people in the operating environment as possible to fully realize the potentials of a robust data-collection system. Too often is a collection capability in the hands of a limited few restricting the scope and utility of data collection. By designing FIST to operate on smartphones, harness the power of Web technologies, and visualize information on a lightweight visualization system, data collection can occur on a much broader scale than previous systems.

Software is distributed via the Web and is accessible on a large number of devices as a result of proliferation of the Android OS used by *Collect*. Device and information management is handled via *FusionPortal* using the latest Web technologies, and *FusionView* manages data visualization. As a matter of scale, FIST can enable collection on thousands, rather than hundreds, of devices and provide the necessary infrastructure for visualizing and sharing the information.

2. Comparative Analysis

In order to fully realize how FIST is a departure from the normal collections systems in use, a selection of government off the shelf (GOTS) and commercial off the shelf (COTS) technology has been selected for comparison. While not exhaustive in nature, the following table (Table 1) highlights key similarities and differences between the selected systems—FIST, I Know Everything (IKE)[1] / Geographic Assessment Tool for Engineering Reachback (GATER) developed by the U.S. Army Core of Engineers, Tactical Ground Reporting System (TIGR) created by the Defense Advanced Research Projects Agency (DARPA), Reality Mobile (www.realitymobile.com), and the Rapid Data Management System (RDMS) Collect by Global Relief Technologies (www.grt.com).

[1] Although the IKE refers to the equipment and the GATER refers to the backend, they are deployed as a single unit and as such, are treated as a single entity in the comparative analysis.

	FIST	IKE/GATER	TIGR	Reality Mobile	RDMS Collect
Description:	Smartphone-based collection, analysis, and visualization system	Ruggedized collection and Web database for Civil Affairs forms	Web-based wiki with a geospatial component for viewing reports	Smartphone-based C2 with video and situational awareness tools	Ruggedized collection and visualization system for form based data
Data formatted for analysis with:	Geospatial, Link, Temporal, and Social Network Analysis	Geospatial and Link Analysis only	Geospatial only	Visualization only	Web-based visualization and geospatial analysis (proprietary C2 system)
Shareable Collection and Analysis with Host Nation Counterparts:	Yes	Not shareable due to CAC card limitations	SIPRnet only. Not releasable	Yes	Yes
User-tailorable:	Yes	Yes, with limitations	Customizable display only	No	Yes
Integration into Intelligence Cycle:	Real-time data viewing and queing of collectors	Real-time data viewing	Real-time data viewing	Real-time data viewing	Real-time data viewing
Integration with other systems:	Yes—export to a variety of analytic packages and databases	Yes—export to GIS capable software only	No	Yes—visualizaton only	No
Collection focus:	Report and relational information based	Report based	Report based	Video and imagery	Report based

Table 1. FIST comparative analysis

This comparative analysis points to the various strengths and weaknesses for several systems with like capabilities of FIST. Although the systems displayed are used in slightly different contexts, no singular system spans across multiple mission types, is as flexible and dynamic, and provides as much capability as FIST.

II. USE CASES

A. USING FIST IN A HUMANITARIAN ASSISTANCE/DISASTER RELIEF ENVIRONMENT

1. Overview

FIST is ideally suited for use in the humanitarian assistance and disaster relief (HA/DR) realm as the system is lightweight, flexible, and is designed to work in a completely disconnected state. FIST enables the collection of data in a remote area that is then transmitted to a reach back center where detailed analysis and planning can occur. From this reach back center, decision makers can make better informed decisions regarding the best approaches for a coordinated response to the crisis and in turn reduce human suffering. As HA/DR encompasses disaster response, disaster relief, humanitarian assistance, and long-term development, the use of FIST in these contexts can vary slightly from the use of the system for a first responder capability to an information collection tool for hazard assessments and identification of reliable partners in relief and reconstruction. As such, this case will focus on the use of FIST in a disaster response scenario in addition to discussing a long-term humanitarian assistance and development effort.

2. Using FIST in a Disaster Response Environment

According to the Center of Excellence in Disaster Management and Humanitarian Affairs *Disaster Response (COE-DMHA)* handbook, written by Dr. Erik Auf der Heide, "Disasters are the ultimate test of emergency response capability. The ability to effectively deal with disasters is becoming more relevant because of factors that tend to increase risk" (Auf der Heide, 1989). The difficulty in responding to disasters lies in the wide variety of problems encountered, to include proximity to the disaster, location of population centers, resources and trained personnel available, and willingness and support of the disaster response units. Along with the aforementioned issues, communications and information flow tends to hamper the efforts of even the most prepared disaster response. In the recently released *Natural Disaster Risk Index of 2010* (Maplecroft, 2010), 15 countries around the world are at "extreme risk" of an impending natural disaster. Of these 15 countries, the majority is in Asia. Organizations must plan and implement technologies and policies now to effectively mitigate and reduce the risk associated with responding to disasters that are just over the horizon.

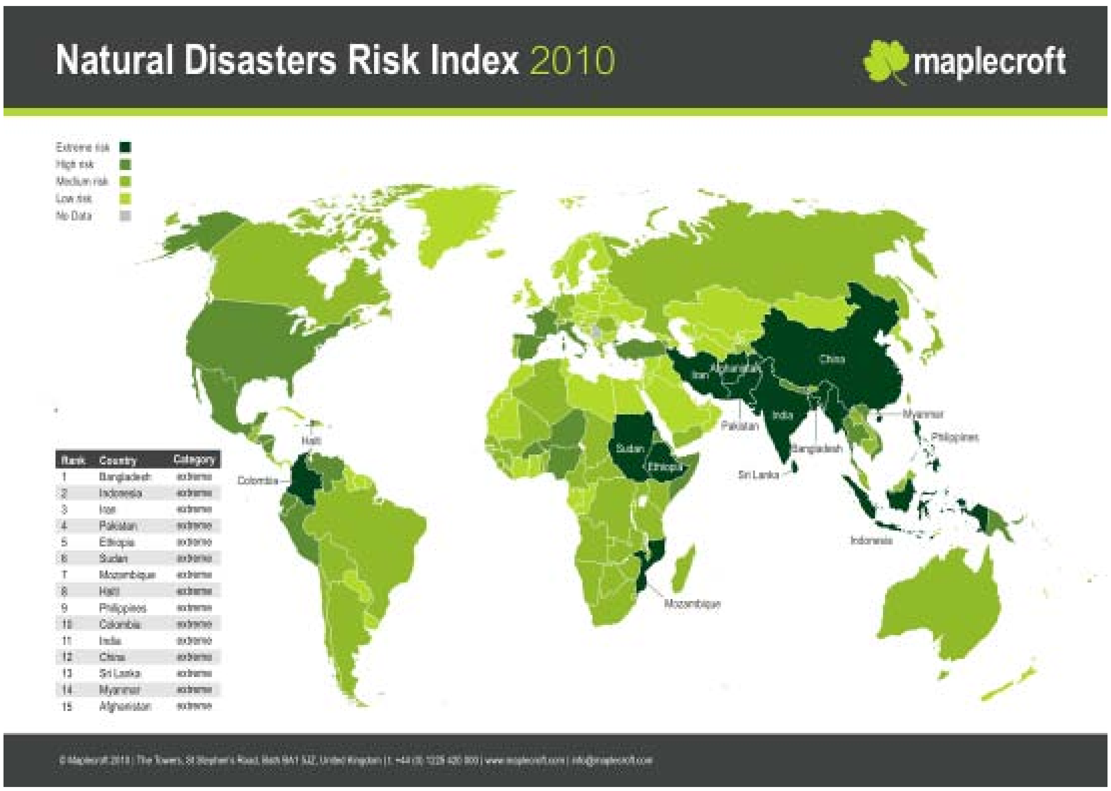

Figure 7. Natural Disasters Risk Index 2010. From (Maplecroft, 2010)

As evidenced by NPS faculty supporting communications networks in the recent earthquake relief efforts in Haiti, a number of organizations arrived on the ground in Port-au-Prince without effective tools for communicating and capturing data needed for decision makers to effectively and efficiently respond to the disaster. Additionally, the language barrier between the affected population and the relief organizations slowed the communication processes and flow of information resulting in delays in effective response.

While many organizations arrived without the adequate equipment needed for information flow and management, several projects cropped up to deal with the massive number of reports flowing from the affected population. One such organization is Ushahidi. Ushahidi is a crowd-sourcing application designed originally for monitoring election fraud in Kenya (Ushahidi, 2010). Given the system's flexibility, a portal was quickly established for monitoring reports from the affected population in Haiti. As of this writing, the portal is still publicly accessible (http://haiti.ushahidi.com/). Ushahidi enables any mobile device to submit reports through a text message, e-mail, or even by using an application distributed by the Android market. The reports are then mapped and various hotspot maps are shown to help determine areas of highest need (see Figure 8).

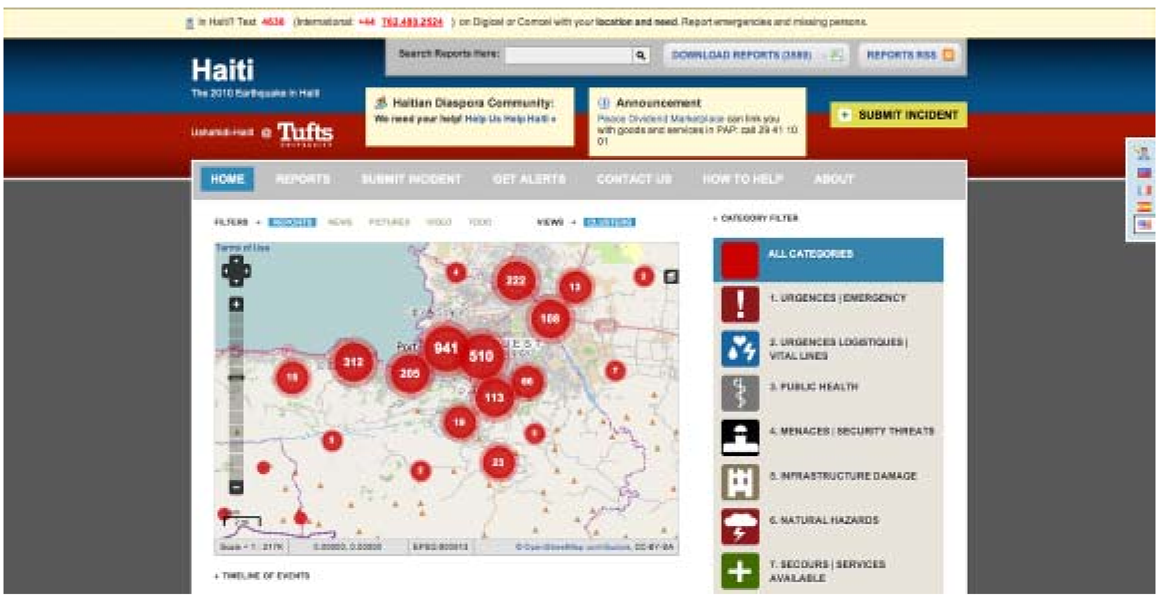

Figure 8. Crisis mapping on the Haiti Ushahidi Web portal. From (Ushahidi, 2010)

While crowd sourcing is advantageous for monitoring elections, oil spill sightings, and other events, it can become extremely problematic for the decision maker to filter legitimate data from noise during a crisis. One of the limiting factors of crowd sourcing is its very design—anyone can submit anything to the system without restrictions. As such, it can become increasingly difficult for responders and disaster management teams to filter reports by importance. There is clearly a need for trained or semi-trained personnel working under traditional organizational structures to capture this data in the field and report it into a system that is specifically designed for information fusion, filtering, and management.

FIST is ideally suited for use in disaster response, as it is designed for efficient field data collection, supports multiple languages (such as Japanese, Korean, Spanish, French, German, and even Swahili provided this capability is enabled), is fully shareable and fully releasable, and is distributed via a model that can enable any smartphone to become a data-collection sensor. FIST enables an organization to specifically tailor collection reports for the disaster at hand instead of forcing the use of templates that may not be entirely adequate for the specific disaster in question. Additionally, the use of *FusionPortal* can enable government, non-government, and commercial entities to work together in a common portal specifically designed for information management and data fusion. While it is not meant to replace other technologies, such as Ushahidi, the two are complementary efforts serving different purposes and audiences. FIST relies on trained personnel using the system for data capture, while Ushahidi and other crowd-sourcing applications enable anyone to report information from the field.

3. Conducting Hazard Assessments with FIST

> Disaster planning is carried out in a climate of apathy and economic restraints. In order to compete for limited expenditures and resources, the need for disaster countermeasures must be justified. In order to circumvent apathy, it is best to focus on predictable and likely events. The accomplishment of these objectives is facilitated by the collection of information about local hazards, the extent to which they threaten local populations, and the ease with which their effects can be averted. (Auf der Heide, 2010)

FIST can enable the collection of hazard assessment data and the visualization of the overlays used for mission planning as recommended by Dr. Auf der Heide. Using a custom collection form, operators can map potential disaster areas quickly and easily and upload the forms to FusionPortal for analysis and fusion resulting in the rapid production of the hazard assessments. These assessments enable the proper preparation needed for effective disaster responses that every organization should be able to produce.

4. Identifying Reliable Partners in Relief and Reconstruction

FIST is a powerful platform for capturing data and transmitting it back to a central repository for aiding in disaster response, but it is equally as useful in its application for identifying reliable relief and reconstruction partners in an affected area. As FIST was originally designed with a specific emphasis on its ability to capture relational data, it is ideally suited to collecting socio-cultural data about a given population. These data, in turn, can identify individuals with high levels of connectedness and social capital who can truly affect the outcome of a relief and reconstruction effort in a particular area by exporting data for analysis from *FusionPortal* in the appropriate format. To fully describe this process, a fictional data set and scenario will be used to illustrate this point using notional FIST collection reports, geospatial analysis, and social network analysis (SNA).

Before moving into the fictional collection and analysis, it is worth pausing to discuss social network analysis and its utility in analyzing relational information. According to Dr. Sean Everton, "social network analysis, then, is a collection of theories and techniques that provide empirical content to social context" (Everton, 2009). Social network analysis is focused on the analysis of relational data using a variety of mathematical formulas that yield various metrics by which the analyst then can devise various hypotheses about the structure of the network and the individual nodes that form the network. Of note, social network analysis differs from the more commonly used link analysis in that it takes in context the strength and weakness of the various ties, looks to explain why such ties play a role in an actor's behavior with regards to its relative position in the network, rather than merely saying a tie exists between two objects. We now turn to the example to understand when and how we would use SNA for a particular operation.

As part of an ongoing development effort in a particular country, a decision maker wishes to determine if the organizations he frequently works with are maximizing the return on investment (ROI) of relief funds being poured into the country. To determine this ROI, he tasks his teams to begin collecting data using FIST by emphasizing the collection of socio-cultural data related to the relief organizations. These organizations traditionally have been engaged in providing reconstruction services, but the effectiveness of these groups have come into question lately as they may not clearly be the best choice for future contracts. The data collected from FIST will be used to evaluate how connected each organization is to the overall relief network in the country and provide a better understanding to the decision maker.

A team equipped with the FIST *Collect* application spends approximately two weeks on the ground conducting interviews and submitting their reports back to *FusionPortal* for analysis. Once in *FusionPortal*, an analyst begins the data visualization process and views the collection reports geospatially. These reports can be viewed directly on the portal or exported for viewing in a geospatial application such as Google Earth (see Figure 9).

Figure 9. Geo-spatial map depicting FIST collection reports

Since the primary focus of the mission is to identify organizations' effectiveness, the analyst will take a closer look at the relational data collected and see if he can form a link between organizations with high levels of connectedness and social capital, and their relative efficiency. The analyst searches *FusionPortal* for relevant collection reports then exports the datasets into the SNA application ORA. Once in ORA, the network is again visualized (Figure 10), this time showing relational data and the networks connectedness. At first glance, the organizations appear to be relatively interconnected, so the analyst looks to determine if any of the organizations scores highly in a metric known as betweenness centrality. Betweenness centrality is measured under the assumption that a particular organization (node) has power over other organizations (node) within the network whenever that organization is located between other organizations on the shortest path. Figure 10 demonstrates betweenness centrality of the organizations in the dataset and colors them to highlight the varying levels of centrality. The organizations that are colored dark blue score highly in betweenness centrality, those with a color closer to red score lower in betweenness centrality.

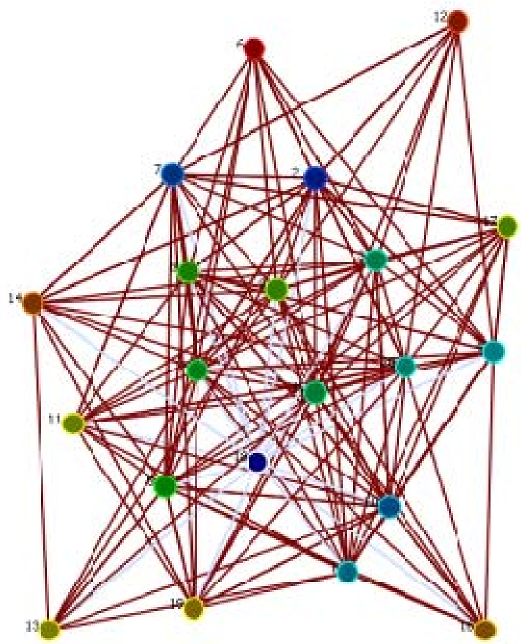

Figure 10. Organization with high betweenness centrality shown in dark blue

From this visualization, the analyst can see how organization 18 lies in a very connected state in the network, as is indicated by the sociogram in Figure 10. Organization 18 is colored dark blue and it scores high in terms of betweenness centrality, although centrality alone does not alone prove that organization 18 is the most effective or efficient relief group. Because it is difficult to fully appreciate the distinction among the organizations, the analyst turns to a standard network analysis report to help explore the full structure of the network.

The Standard Network Analysis report is an output obtained by analyzing the network in ORA. The SNA report provides a table showing how individual nodes score on six different metrics—betweenness centrality, closeness centrality, eigenvector centrality, in-degree centrality, out-degree centrality, and total degree centrality—and ranks the nodes from 1–10 in how high each scores in the various metrics. While the specifics of what defines each type of centrality are not covered in this thesis, it is worth mentioning that centrality is best described by the following.

> Most social networks contain people or organizations that are more central than others and because of their position, they often enjoy better access to information and better opportunities to spread information. Social network analysts have identified several measures of centrality, each based on different assumptions of what it means to be more central. (Everton, 2009)

From this analysis, it is clear that organization 18 ranks highly in a number of different SNA metrics and has a high probability of being an organization that is well informed, highly connected, and a potentially reliable partner for aid and reconstruction efforts given their position in the network relative to other organizations (Figures 11 and 12). The analyst completes his report and submits it to the decision makers for action.

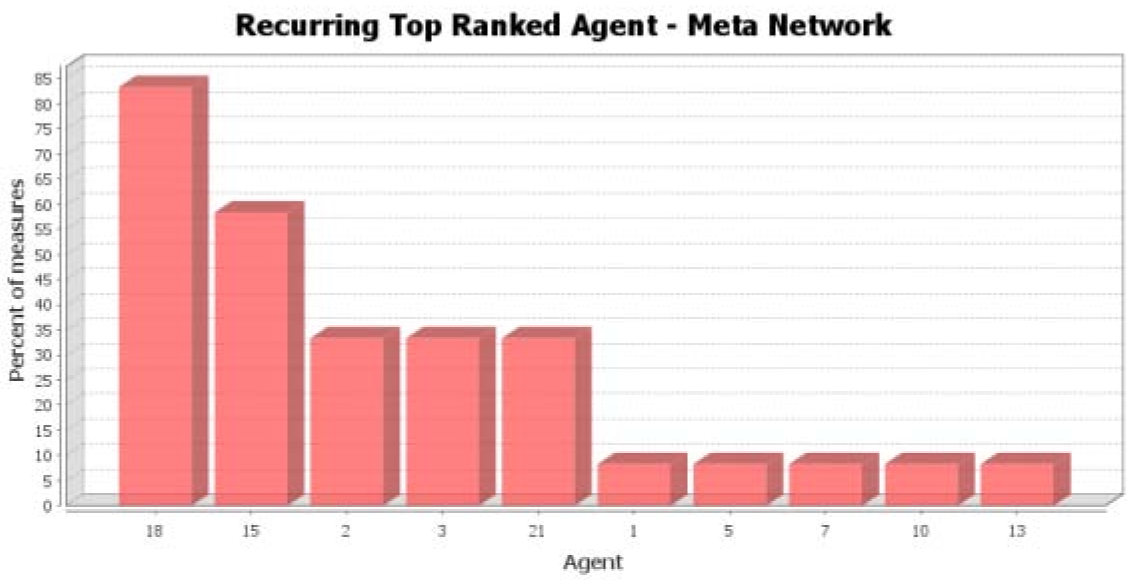

Figure 11. Recurring top-ranked agent showing 18 scoring highly

Key Nodes Table

This shows the top scoring nodes side-by-side for selected measures.

Rank	Betweenness centrality	Closeness centrality	Eigenvector centrality	In degree centrality	Out degree centrality	Total degree centrality
1	18	15	15	2	15	18
2	21	18	2	18	18	21
3	7	3	18	21	3	15
4	10	5	3	1	5	10
5	1	10	20	7	10	2
6	4	9	1	11	9	7
7	20	4	5	6	4	3
8	3	20	9	8	20	4
9	15	19	10	14	19	5
10	2	21	21	10	21	20

Figure 12. Key nodes table for standard network analysis report

It is important to note that the full analysis of this network is not represented in this document and some of the assumptions about network structure are not fully expressed. It would be wrong to categorically label organizations that score high in centrality to being the most interconnected or in the know based only on the metrics mentioned above. These caveats aside, the data are merely one example of a use of FIST, how data are collected, and how analysis can be enabled through *FusionPortal* to facilitate the identification of reliable partners in a relief and reconstruction effort.

5. Conclusion

FIST provides a unique capability for collecting, processing, sharing, and analyzing data that spans the entire spectrum of HA/DR environments and its use is merely limited to the imagination of the using organization. FIST has been tested successfully as a technology evaluation tool in Haiti, will be used in a scripted environment for earthquake response in Manila during a 23-nation workshop entitled Pacific Endeavor (see Data and Analysis for full description of Pacific Endeavor, 2010), and is slated for a number of other future deployments around the world.

B. USING FIST IN A DYNAMICALLY CHANGING ENVIRONMENT

1. Understanding the Local Population

> While Social Network Analysis (SNA) has been used extensively for optimizing organizational structures within corporations, and more recently for targeting dark networks of terrorists or insurgents, SNA also offers an effective means to enhance Civil Affairs assessments to assist at-risk communities more effectively and with greater credibility, and to better disseminate sociocultural information to other U.S. and host nation forces. (Machiela, 2010)

Ties built through kinship connections, tribal relationships, religious education, and other forms of normal, everyday association *form the basis of* indigenous forms of association, local means of organization, and traditional methods of mobilization (Simons and Tucker, 2004), yet we have no effective means to collect, process, or share this kind of information. Our current data collection efforts tend to focus on individual actors in and their attributes such as age, occupation, and skill set. But without information about the relational ties that bind people together, analysts are unable to describe or track a network, or more importantly, make predictions what the network might do under varying conditions.

Socio-cultural dynamics on the other hand begins with the collection of relational data such as kinship, friendship, and community ties. It is followed by "traditional" area assessments and gaining an understanding of the needs of the population. By collecting information about the people, their relationships, their behavior, how they are interrelated, and the environment in which they operate, the intent is to improve our ability to map the human terrain.

2. Determining Population Needs, Friction Points, and Networks Within

As mentioned previously, the Tactical Conflict Assessment and Planning Framework (TCAPF) is a framework for determining, among other things, a particular village's needs based on an analysis of the responses given to four questions. These questions relate to the changes in the village's population, the cause of the change, the biggest challenge facing the village, and the trusted partners who can help alleviate or mitigate this problem. The data in turn is collated and analyzed at a macro level for the purpose of guiding commander's planning and decision-making processes. TCAPF is currently collected using laptops running Microsoft Excel, but a module has already been implemented in FIST for collecting and processing TCAPF data.

In addition to determining village needs, FIST can enable the operator to capture information about the population (who is related to whom), and the environment (descriptions of the territory in which people live). Because data are collected from the entire population, extracting the dark network (the subset of the total network that represents the criminal or insurgent actors) from the light networks (the subset that represents the general law-abiding population), it might be possible to analytically differentiate between the two networks. Since insurgents live, work, and hide amongst the population, overt data collection followed with focused analysis may can enable the war fighter to identify the dark networks hiding in plain sight.

From this massive data set, a trained analyst can begin to conduct in-depth analysis on the population using a variety of tools and techniques. Through the use of an integrated approach using geospatial, temporal, and social network analysis, the dark networks can be extracted, analyzed, and potentially disrupted. In order to further develop the techniques used by analysts for disrupting dark networks, the following section will focus on a specific example of network disruption using social network analysis.

3. Using Social Network Analysis to Disrupt Dark Networks

After a dark network has been identified, the next step is to analyze this network in depth in order to recommend a course of action. Although *Collect* enabled a large volume of data to be gathered, *FusionPortal* is needed to sift through the mountainous volume of data and ready the information for export into a variety of analytic file formats. Once exported, the datasets are again analyzed using social network analysis, the discipline previously described in an earlier section of this thesis.

In order to fully elucidate how an analyst would go about sorting through and attempting to recommend a strategy to combat a dark network, we turn to a description of Noordin Mohammed's terror network as it appeared in the International Crisis Group document entitled "Terrorism in Indonesia: Noordin's Networks" (ICG, 2006). The document, an unclassified, open-source accounting of terrorist activities surrounding four major incidents in Southeast Asia, provides a robust opportunity to create a data set and then use social network analysis on the data to test a variety of theoretical methods for intervention and disruption. The article details the relationships and ties that existed in Noordin's network as of 2006 and includes geospatial and temporal references as well.

The data used in the following analysis of Noordin's network was coded manually using a number of spreadsheets requiring several weeks of time with approximately 20 students working on a class project. One of the major goals of FIST is the automation of the data entry and coding procedures required for this level of analysis. Using automated systems and various database manipulation techniques, the processing of the relational can be significantly improved and the time from collection to analysis is greatly reduced, although the exact amount of time has yet to be determined.

In order to determine an effective way to disrupt Noordin's terror network using SNA, one can turn to "Strategies for Combating Dark Networks" (Roberts & Everton, 2009).In their work, Roberts and Everton highlight a framework to use when disrupting networks. This framework can be seen in Figure 13.

Approach	Kinetic		Non-kinetic			
Leadership	U.S	Host Nation	U.S.		Host Nation	
Strategies	Targeting	Capacity Building	IB	PsyOp	IO	Rehab

Figure 13. A framework for COIN Strategies using SNA. From (Roberts & Everton, 2009).

From this framework, Noordin's network was analyzed to determine if there was an effective means for conducting non-kinetic targeting of his network. To determine if his network was susceptible to non-kinetic targeting, analysis focused on the kinship, friendship, school, and religious ties in Noordin's network both on an individual and organizational level.

For the individual level analysis, we focused primarily on determining the betweenness centrality, closeness centrality, and eigenvector centrality for individuals in Noordin's network to ascertain if there were individuals susceptible to non-kinetic targeting. A variety of reports were generated and analyzed from the Noordin dataset, and it became apparent that a number of individuals in Noordin's network scored highly in the three metrics chosen (see Figure 14). However, the analysis appeared to demonstrate that it would be more effective to target Noordin's network from an organizational level rather than at the individual level as the individuals in the core cells of the network were extremely interconnected and dense suggesting that directly targeting these members with non-kinetic means would prove to be difficult.

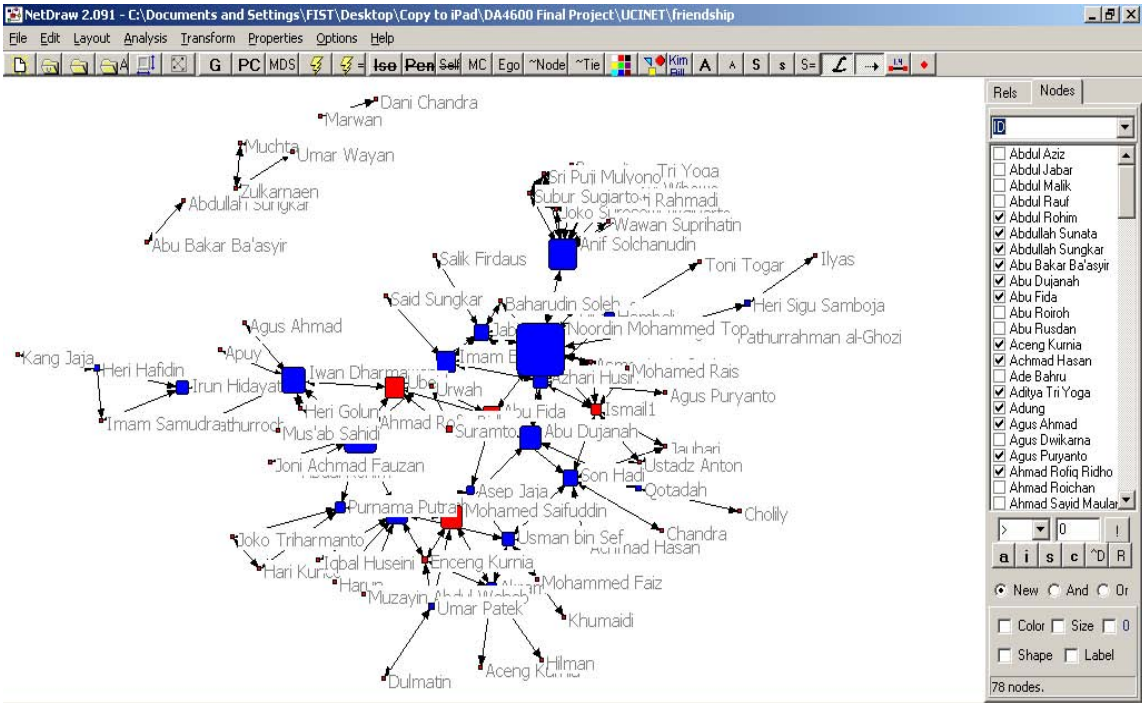

Figure 14. Friendship ties in Noordin's network

For the organizational analysis, we looked at the education and religious ties in Noordin's network. The focus of the analysis was on the various schools and mosques where individuals in Noordin's network met, trained, and communicated. From the schools listed in the article, it became apparent that only three form the core of the recruiting locations for Noordin's network—Luqmanel Hakeim, Pondok Ngruki, and Universitas An-Nur—as seen in Figure 15.

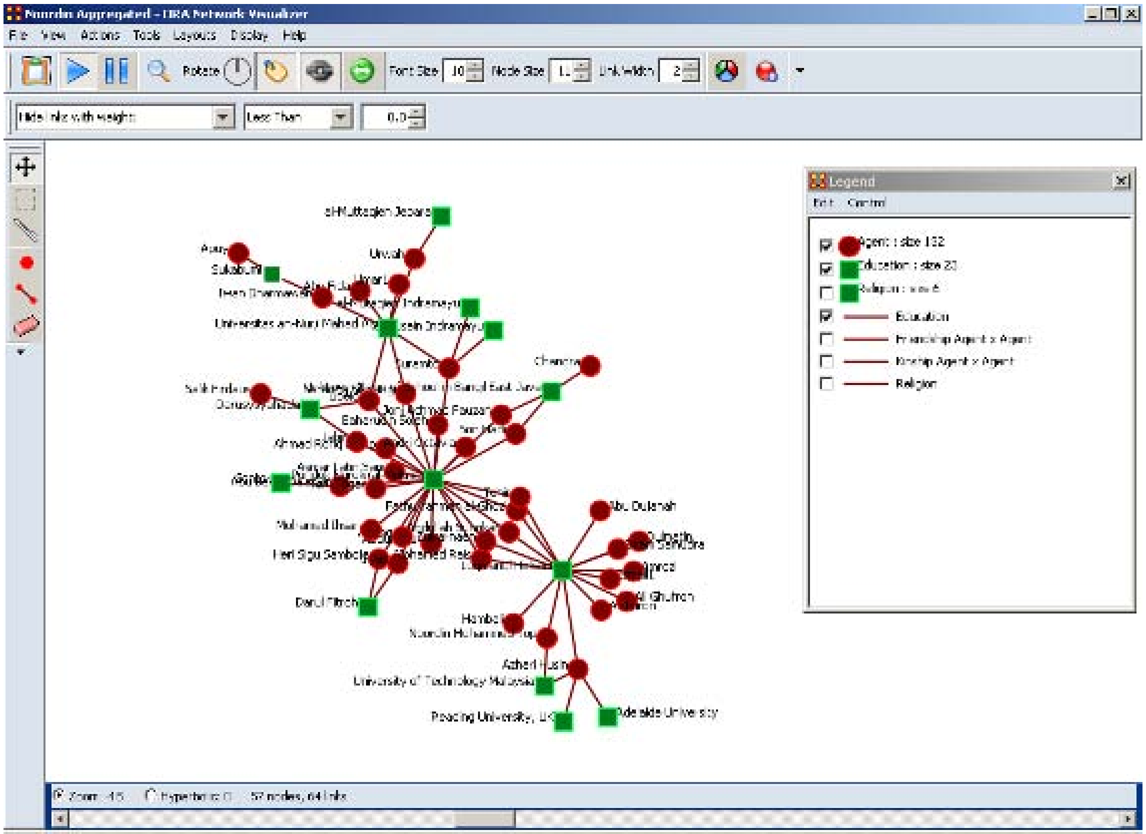

Figure 15. Educational ties in Noordin's network

After visualizing the educational ties in Noordin's network, we turned our attention to visualizing the educational ties in the network, as seen in Figure 16. Based on the visualizations and further analysis, it appeared as if the educational institutions formed the basis of recruitment and foundation upon which the network was formed.

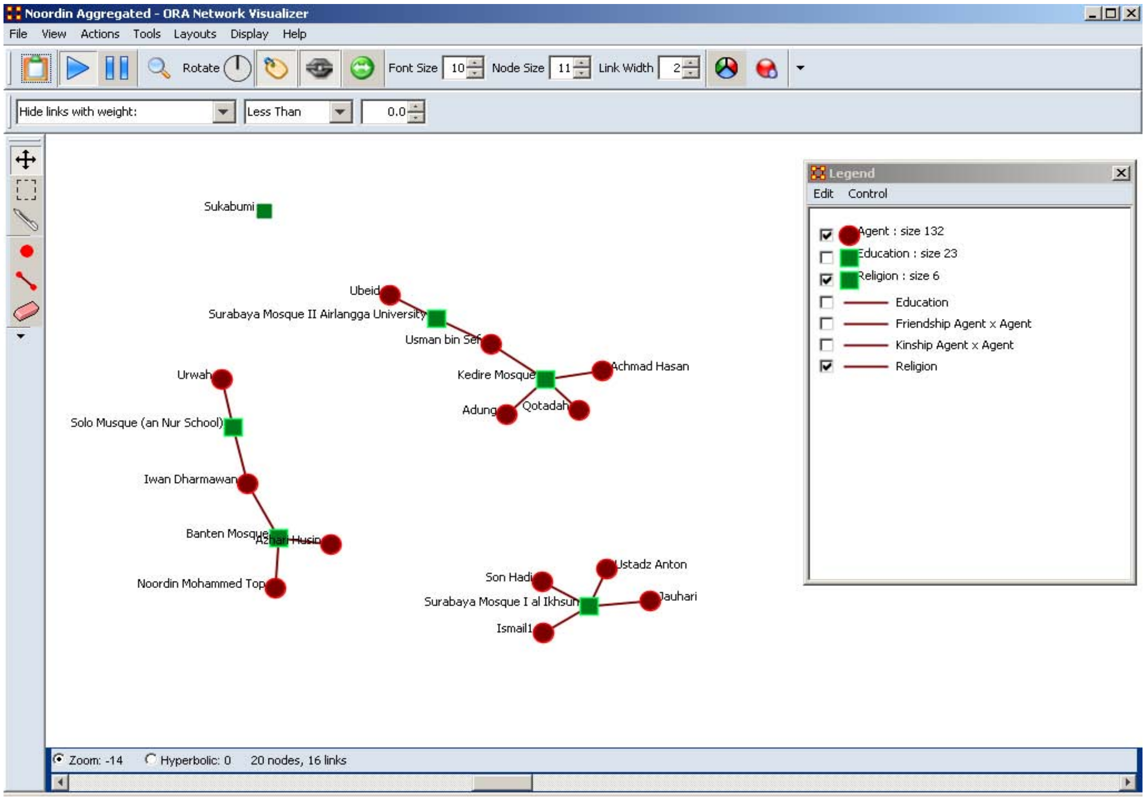

Figure 16. Religious ties in Noordin's network

The analysis appears to suggest that schools influenced Noordin's terrorist network much more than mosques did. The analysis suggests the targeting of institutions that help support Noordin's network using a variety of indirect approaches. For example, an information operations campaign could be devised to target followers of the school to dissuade them from attending, and instead offer an alternate school with an alternative point of view, or the schools could be targeted by intelligence activities as a source of obtaining valuable intelligence on the inner workings of the network. The goal for this indirect strategy would be the deprogramming of the environments that enable radicalism to flourish and offer an alternative.

As shown in the analysis of Noordin's network, SNA allows for a different perspective on the available data and it provides another tool useful for understanding and disrupting violent extremists. It is only through the understanding, targeting, and disruption of these dark networks that we can be successful in defeating terrorist and insurgent organizations.

III. DATA AND ANALYSIS

A. PROTOTYPE DESIGN—FIST LIGHT

While waiting for the development of FIST to officially begin, a number of open-source and free tools have been integrated to simulate a lighter weight version of the functionality desired in the fully developed FIST. *FIST Light* is capable of collecting customized form-based data using an Android smartphone, transfer the information to a database residing on Google App Engine, collate the information in a visualization table known as Google Tables, and create a network Keyhole Markup Language (KML) link for display in a number of different applications including Google Earth. This toolkit effectively allows a user to collect data in the field and have a remote location visualize and analyze the data collected. *FIST Light* is limited, however, in its capabilities versus the fully developed FIST system as there is no current means of extracting relational data, displaying the information in any software package other than geospatial software, and the system is reliant on a number of systems that are not owned or controlled by the end user. As FIST transitions from these tools to a more robust system, the open architecture and ease of use with which one can operate *FIST Light* will be included.

FIST Light relies on a number of open-source and free, commercially available software packages and capabilities to function effectively. The first of these tools, ODK Collect and ODK Aggregate, are provided from the Open-Data-Kit (ODK) project out of the University of Washington (Project Change, 2010).

1. ODK Collect

ODK Collect is an Android-based open-source application that uses an extensible markup language (XML) form specification known as XForms to collect, process, and transmit media rich forms collected to a remote server. Currently, the software supports the ability to collect geo-coordinates, audio, video, still imagery, and barcodes in addition to supporting multiple languages in the form definitions. ODK Collect is capable of working in a completely disconnected state and will store collection reports until the operator has regained network connectivity. Along with its ability to transfer information via the cellular network, ODK Collect enables the transfer of information via a Universal Serial Bus (USB) cable as well as transferring information via an 802.11 Wi-Fi hotspot. In addition to the handheld application, the ODK project has released another open-source-application for data management known as ODK Aggregate.

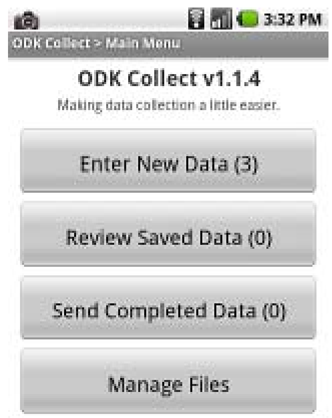

Figure 17. ODK Collect main menu

2. ODK Aggregate

ODK Aggregate is the server side application for *FIST Light* and it can be installed on the free Google App Engine infrastructure—Appspot.com. Aggregate manages the handling of form data submissions and serves as the form repository. Aggregate enables a user to deploy forms to any number of devices, provides a database for information storage and retrieval, and integrates with other external services such as Rhiza Insight, Google Spreadsheets, and Google Fusion Tables. For *FIST Light*, integration with Google Fusion Tables was used to create the KML link for display in Google Earth, All Partners Area Network (APAN), and others. ODK Aggregate does have limitations, however, in comparison to the fully architected and developed FIST system. ODK Aggregate can only run on the Google App Engine cloud without extensive code re-write. Security policies and application behavior is largely out of the hands of the developer and data security cannot be guaranteed given the dispersed nature of the Google cloud architecture. Additionally, the ability to export data in formats other than CSV or KML is not incorporated in ODK Aggregate. Nevertheless, ODK Aggregate provides a useful framework for the beginning stages of information management in addition to providing a basic, easy to understand management interface (see Figure 18).

Figure 18. ODK Aggregate form manager interface

3. Google Fusion Tables

Fusion Tables is a Google Labs product that enables large volumes of data to be collated, sorted, searched, and displayed visually on maps within its environment. *FIST Light* does not use Fusion Table for its database capabilities (a function currently provided by Aggregate), but uses the KML network link functionality to pass the information off to a richer geospatial visualization toolset than is offered by Fusion Table (see Figure 19). The ability to share information via a KML network link will be incorporated into *FusionPortal* as this capability provides a significant visualization capability across a wide range of systems in use today.

Figure 19. "Place" table as shown in Google Fusion Tables

4. Google Earth

Google Earth is the visualization tool of choice for *FIST Light* as it is widely used throughout the world, is free, and is very easy to use. Additionally, Google Earth accepts KML links without any additional configuration and displays the geo-referenced form data on the globe easily. Collection reports are visualized in Google Earth via the KML network link provided by Fusion Tables and examples of the output can be seen in Figures 20 and 21.

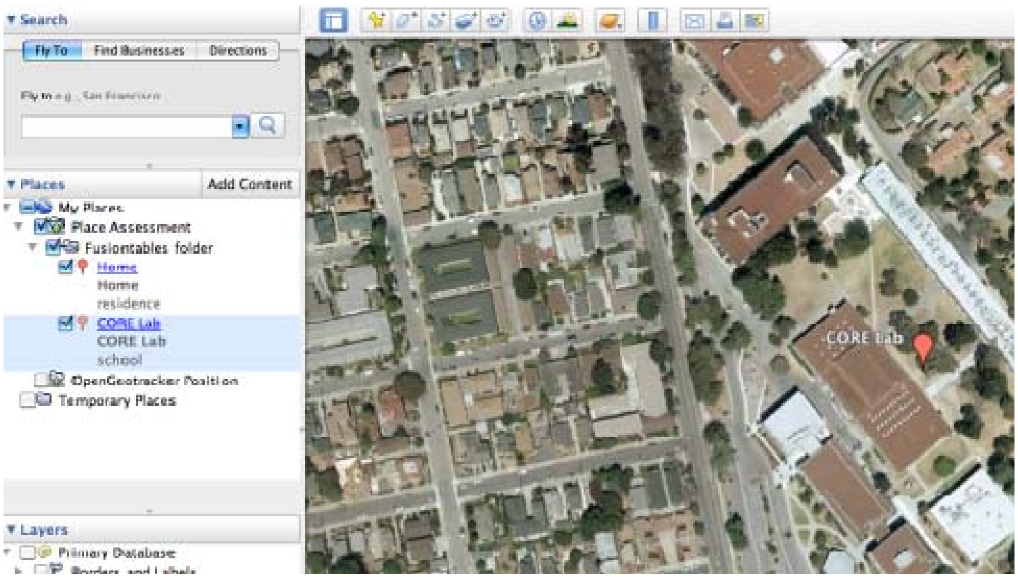

Figure 20. Image of collection report displayed in Google Earth

Figure 21. Additional details displayed when selected in Google Earth

FIST Light is a robust, reliable middle step in the development process of FIST and has allowed for a variety of tests to take place before the official application is released. Among other things, *FIST Light* has been used to validate collection forms, test network connectivity throughout the U.S. and Asia, provide unique insight into various smartphone capabilities and limitations, and offer a level of general exposure to the power of using smartphones for conducting field based data collection.

B. CARAT THAILAND 2010

1. Exercise Support Overview

The Naval Postgraduate School Pacific FIST team deployed to the Sattahip Naval Base in Thailand from 13–21 May to participate in exercise Cooperation and Readiness Afloat Training (CARAT) 2010. The Naval Postgraduate School team consisted of Mr. James Ehlert, Mr. Ed Fisher, and Captain Carrick Longley. Additionally, Mr. Ivan Cardenas of Kestrel Technology Group and Mr. Cyril Berg, Mr. Paul Trist, and Mr. Aaron Aamold of AeroVironment (AV) worked alongside the Naval Postgraduate School team. The combined team was tasked with demonstrating smartphone data collection and management, information fusion and Unmanned Aerial Vehicle (UAV) technology respectively. Using the AeroVironment Puma All Environment (AE) UAV, the Naval Postgraduate School team was able to demonstrate an integrated HA/DR and reconnaissance platform using low cost communications solutions.

2. Test Plan

a. Purpose

The objective of the FIST project is to successfully develop a field data-collection system using COTS smartphones and a Web based data fusion environment for improving data collection, processing, analyzing, and sharing of information. *FIST Light* is an intermediate prototype that uses open-source and free software to replicate the data collection and visualization (geospatial only) component of FIST.

b. Test Description

The purpose of the CARAT test was fourfold. *FIST Light* was tested during CARAT Thailand to determine, among other things, validity of assessment forms, network connectivity and throughput requirements, smartphone capabilities and limitations, and the ability to visualize information collected from smartphones at a Tactical Operations Center (TOC). The data collected during CARAT Thailand was driven by the notional requirement of the Combined-Joint Task Force 73 to collect relevant data that would provide better situational awareness of the medical centers located throughout the Sattahip area.

c. Requirements

For the exercise tests, the following equipment was required: (2) Motorola Milestone smartphones with GSM data connectivity, (1) *FusionView* field laptop with Internet connectivity, and (1) van for transportation.

d. Measures of Performance and Effectiveness

(1) Technical Feasibility: Is the *FIST Light* capable of successfully connecting and communicating collection reports the GSM data network? Can *FusionView* accurately parse the data communicated to the server via a network link?

(2) Deployment Feasibility: Can *FIST Light* / *FusionView* be configured to operate in a tactical environment? What equipment is required to support deploying FIST / *FusionView* in a variety of mobile/static locations?

(3) Ease of Use: How easy/difficult is the user interface on the smartphone to collect data? Can the user easily switch between network modes via the phone? Do the forms used accurately reflect/support mission requirements?

(4) Portability: Is the device portable? Is it easily configurable? What specialized equipment and configuration is required for the device to operate?

(5) Reliability: Does the device perform reliably? What is the reliability of the hardware components? How often does the software crash and under what circumstances? How robust is the network upon which the various data services ride? Can the network handle various traffic intensity/user loads?

(6) Robustness: Can *FIST Light* capture the data requirements in a tactical situation? Does *FIST Light* provide sufficient redundancy in the event of nodal failure?

(7) Accuracy: Is the data passed over the FIST application accurate?

3. Test Results

a. Technical Feasibility

FIST was able to collect, process, and transmit over 30 media rich collection reports (photographs and geospatial data in addition to user entered information) via the local cellular network, USB interface, and an 802.11 Wi-Fi hotspot. Additionally, the FusionPortal server provided the appropriate network interface for report parsing for both Google Earth and *FusionView*.

b. Deployment Feasibility

FIST was configured to collect data for disaster preparedness (heavy emphasis on health services in the Sattahip area) using its ability to handle custom collection reports. FIST can be deployed anywhere in the world using only a smartphone, the FIST *Collect* software, and a local GSM subscriber identification module (SIM) if passing of data over the local infrastructure is needed. Because the server is located in the Internet "cloud," only a connection to the Internet (whether through cellular, Wi-Fi, or other means) is needed when collection reports are transferred. The current configuration works entirely disconnected and does not require any connection to collect, process, and store the data. *FusionView*, the lightweight visualization and sensor fusion system used for displaying collection reports only requires a laptop for use in its minimal configuration. Depending on the mission set and configuration, the field version of *FusionView* is not necessary for operations and *FusionPortal* can suffice.

c. Ease of Use

The FIST collection software uses a lean user interface that focuses entirely on data collection and data entry. Realizing that a smartphone poses unique restrictions on a user given its screen size and input device (a finger and small keyboard), the design of the interface is minimalistic but functional. For the CARAT test, a lightweight health services collection form was used.

d. Portability

The Motorola Milestone was used for the collection in Sattahip. The phone fits easily into one hand and weighs relatively little. Other than loading the FIST software onto the device and updating to the latest forms, no other equipment or software is needed—the system is entirely self-contained.

e. Reliability

The majority of the reliability issues related to FIST is a product of the smartphone choice and operating system build rather than one of the reliability of FIST. The phone operated for several hours a day (up to 10 on a single charge) without a single crash or restart necessary. Average temperatures in Thailand were well over 100 degrees, and the phone showed no signs of ill effects.

The cellular network in Thailand did prove to be a bit unreliable at times for transferring data, but the phone itself maintained a connection to the network throughout the mission, and the network enabled collection reports to be transferred most of the time.

f. Robustness

Because of the unique nature of the customizable collection forms, the data provided by FIST can be extremely robust or minimal, given the situation and configuration. For purposes of system testing, a form was built to capture a location name, coordinates, details of the location, operator comments, and a photograph of the location.

Given the relatively low cost of the device, equipment/nodal failure is fairly easy to correct and plan for. There were three Milestones used during CARAT—two primaries and one backup—but no failures were recorded from the devices.

g. Accuracy

Accuracy of information is largely a product of accurate input at the operator level, but system testing and development plans will enable reliability checks through FusionPortal. At the bit level, however, FIST uses the Transfer Control Protocol for sending information to its server and reliability is built into the protocol.

4. Data Collection Overview

In order to demonstrate the utility of using smartphones for data collection for disaster response preparedness, the FIST team focused on the collection of health related data in and around the Pattaya area (closest major city to Sattahip Naval Base) in Thailand. A series of reports were collected on hospitals, medical and dental clinics, and the availability of pharmacies for medical supplies and were mapped in both Google Earth and *FusionView*. Once collected, the information was available for the operations center aboard the Royal Thai Navy (RTN) frigate—the HTMS Naresuan—in real time.

The Motorola Milestones (phones used to run *FIST Light*) were extremely reliable for data collection and required little troubleshooting to keep the software running. However, some problems were encountered with the Kingdom of Thailand's firewall preventing some collection reports from being sent to the server. Future incorporation of a Virtual Private Network (VPN) and a secured socket layer (SSL) connection should prevent future disruptions in FIST collection.

5. FusionView Integration

Integration with *FusionView* went seamlessly and FIST collection reports were visualized in real-time along with the UAV Cursor-on-target (COT) feeds and Wolfpack II radio sensor fusion occurring simultaneously. Figure 22 demonstrates *FusionView* tracking a UAV and a ground vehicle at the Sattahip Naval Base. Enhanced integration testing with *FusionView* during Pacific Endeavor 2010 in August is planned.

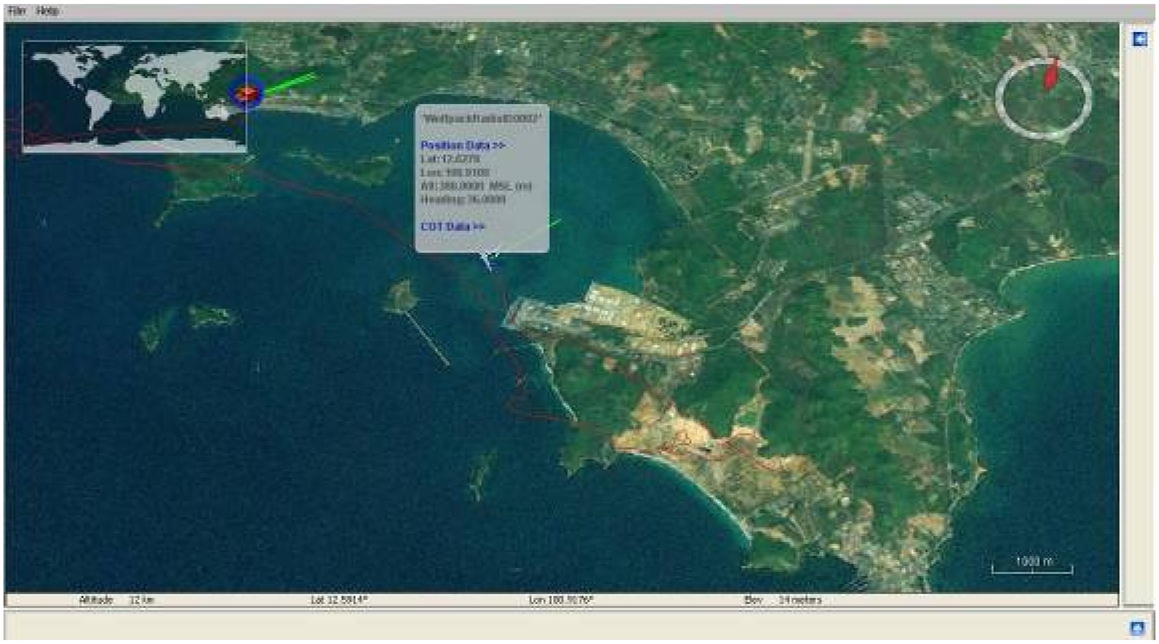

Figure 22. *FusionView* tracking UAVs and ground vehicles

6. UAV Integration

As part of an ad-hoc test, two Motorola Milestones were attached to the Puma AE UAV and flown over the test area. The UAV was tracked at the RTN frigate HTMS Naresuan in both *FusionView* and Google Earth and the flight was recorded using the camera video recording capability.

For the flight test, two Milestones were attached to the aircraft—one on the wing and one on the top of the fuselage. The location of the aircraft was transmitted via a cellular data connection and the other phone recorded video without transmitting any data. The two phones were configured with the following software loads: one used an open-source location tracking software for the Android phone and the other phone used the built-in video recording capabilities of the Milestone. A Web server was used to capture the phone's location data and create a network link for mapping into Google Earth.

The UAV was successfully tracked at the frigate, but there was a slight delay in location updates (the minimum update is currently 5 seconds). Some spotty cellular coverage around the bay led to transmission delays and buffering of data points (noticeable at approximately 6 miles offshore), but the phone continued to collect data without a cellular connection and transmitted the data to the server upon a resumed connection. Additional software constraints prevented the capture of elevation data, but source code modifications can enable this functionality for future tests.

The video recording of the flight was of exceptional quality (High Definition 720p) in comparison to the camera on the UAV, but the lack of pan/tilt and remote software control hindered the ability to manipulate the camera in flight. Bandwidth limitations of the local cellular network prevented useable video streaming from the aircraft. Future tests can incorporate the smartphone with software designed specifically for the remote control and streaming and can potentially pass data through the UAV control link. Nevertheless, given the nature of the relative short planning and integration of FIST with a UAV, the test was a success and future flight integrations are planned.

C. PACIFIC ENDEAVOR 2010

The Multi-National Communications Interoperability Program (MCIP) is an annual U.S. Pacific Command (PACOM) sponsored workshop where a number of countries from across Asia gather for the purposes of interoperability testing surrounding a common theme. For 2010, the MCIP workshop—known as Pacific Endeavor—is based around a fictional earthquake in the Philippines and a 23-nation disaster response effort. In support of this workshop that will occur in August, FIST will be used for real-world data collection and scenario injects with two teams—one in Manila and the other at the Changi Command and Control Center (CC2C) in Singapore.

1. System Integration With the All Partners Area Network (APAN)

The All Partners Area Network (APAN) is a collaborative environment for real-time information exchange among partners using an unclassified portal. For Pacific Endeavor 10, APAN is being used for information exchange during a simulated disaster response. In support of this year's workshop, a scenario has been constructed around a notional earthquake centered in Manila, Philippines. The earthquake devastates a majority of the city and 23 separate nations respond to assist immediately after the disaster occurs. Using the Singapore Command and Control Center (CC2C), the various military leaders from the 23 different nations must cooperate and share information to maximize effectiveness and coordinate the response effort in Manila.

In support of this scenario, FIST will be used to collect data, in real time, in Manila to relay to the CC2C. In the CC2C center, a team of collectors will be managing the information visualization component of FIST and its use in helping drive decision points for the training audience.

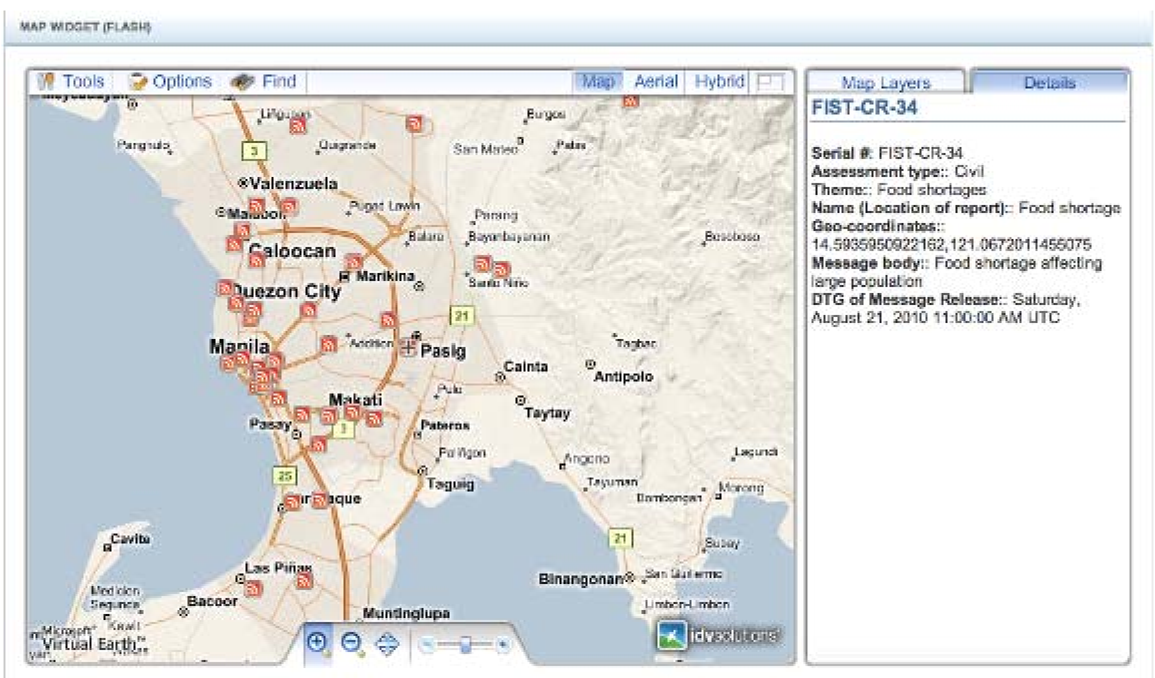

Figure 23.   Example collection report for PE10

The FIST data collection in Manila will be transmitted back to the CC2C in Changi via FusionPortal and a network Keyhole Markup Language (KML) link. This link will be displayed in APAN via the map viewer interface. The actual format and view of the collection report displayed in APAN can be seen in Figure 23 and Figure 24.

Figure 24. APAN map interface for PE10

D. FUTURE TESTING AND EMPLOYMENT

1. Republic of Philippines

a. Concept of Support

The Republic of Philippines proof of concept is a focused effort based on gathering and analyzing information to guide United States (U.S.) and Host Nation (HN) actions for maintaining local security and stability and denying development of hostile activity as per the missions need statement. Based on project sponsorship from Special Operations Command Pacific (SOCPAC), the proof of concept will focus on the initial application goals to include real-time and remote data collection for analysis of Socio-Cultural Dynamics (including social network modeling), Civil Affairs including infrastructure inspection, disaster preparedness and a popular assessment of U.S. funded in-country infrastructure.

b. Mission Needs Statement

SOCPAC has a requirement to collect and assess relevant SCD factors that can influence SOCPAC's mission accomplishment positively or negatively. This capability involves (1) determining collection requirements, (2) collection, (3) analysis, (4) dissemination and (5) integration of this SCD knowledge into the planning process. SOCPAC currently has significant capability shortfalls in all five areas as they relate to SCD.

SOCPAC is working with the SCD community of interest (COI) to develop required capabilities (technical and subject matter expertise) in this area. One of SOCPAC's key SCD COI members is the Naval Postgraduate School, which is developing FIST to greatly enhance SOCPAC's overall SCD capability.

FIST is an unclassified system, unlike current hand-held collection systems that only reside on SIPR. This allows SOCPAC to expand its SCD network to include host nation personnel, students, etc., which will greatly enhance our SCD information collection capability. Furthermore, it allows us SOCPAC to share information with the various host nations. SOCPAC envisions this capability supporting a wide range of stability, counterterrorism, counterinsurgency and other missions in the PACOM Area of Responsibility (AOR). While not limited to the following, this information/knowledge will be especially useful for enhancing and assessing SOCPAC's Civil Affairs operations, psychological operations, and information operations, thus informing planners and operators on areas that may need to be adjusted.

2. Afghanistan

a. Concept of Support

FIST will be employed on a small-scale effort in Afghanistan in support of the newly established village defense initiative and help support the collection and analysis requirements of the Operational Detachment Alpha (ODA) teams operating down range. While FIST is still in its prototype stages, it will be employed to demonstrate the utility of incorporating SCD collection and analysis in the ODA planning process in addition to providing them with a unique technological capability for capturing EI. Due to operational security concerns, further details of the Afghanistan effort cannot be further elaborated in this document.

IV. RECOMMENDATIONS AND CONCLUSION

A. RECOMMENDATIONS FOR FOLLOW-ON RESEARCH

While the FIST testing and development to date has highlighted the benefits of rapid prototyping, a number of areas were not as heavily emphasized for initial tests. Follow-on research is recommended to more closely focus on these areas as the FIST system is further developed.

1. System Security

The first recommended follow-on work focuses on a detailed analysis of the security features of FIST. Analysis should focus on both data at rest and data in motion. Research should analyze virtual private networking techniques with mobile devices, on device data encryption, implementation of secure socket layer (SSL) technology in Web sessions, and a detailed look and recommendation of best of breed commercially available solutions for integration in FIST with an eye towards maximizing security while still allowing for the widest distribution of the system—both within and external to the United States.

2. Employment in the Department of Defense

The second recommended area of emphasis for future development should focus on the implementation of the FIST in a larger context within the DoD. Research questions should be focused on how best to use FIST across a wide variety of operational environments, the training and periods of instruction needed to fully realize the potential of the system within the various service organizations.

B. CONCLUSION

> Culture matters greatly. This is yet another claim that is not unique to irregular warfare, but is of greater significance in that mode of conflict. Since irregular warfare is above all else a contest for the acquiescence and allegiance of civilian locals, their beliefs, values, expectations and

> preferred behaviors are authoritative. If we do not know much about those beliefs and values, we are unlikely to register much progress in persuasion, except by accident. Indeed, by behaving like strangers in a strange land—true aliens—our regular soldiers and officials are as likely to do more harm than good to their mission. (Gray, 2007)

The goal of the FIST project has been to improve on the collection process to enable a better means of analyzing information. From its very inception, FIST has aimed at solving the problem of how we better understand a population and an environment using technology to facilitate our understanding. Since those beginnings, a large amount of work has been dedicated to not only determining how best to architect the technology but also how we can implement the technology to maximize its effectiveness. Whether collecting information in a disaster response environment, helping conduct a popular assessment of a village, or providing unique insights to a commander, FIST continues to innovate and improve on the concept of building a hardware and software knowledge management system.

FIST is capable of providing the much-needed link between collection methodology and emerging technology that can enable the cultural sensitivity and awareness espoused by Colin Gray. With the development and implementation of the SCD collection module and a fully developed collection methodology, FIST can help bridge the gaps in understanding that cross cultures, languages, and information divides. LTG John Mulholland, Commanding General, U.S. Army Special Operations Command, remarked that FIST has the potential to be a game changing capability and would like to see FIST in the hands of every Special Forces operator. From the tactical to the strategic, FIST enables the war fighter, the decision maker, and the systems of today and tomorrow.

The tests conducted with *FIST Light* have demonstrated that suitability of smartphones for collecting, processing, and visualizing information. The capabilities resident in phones enable a more complete collection capability than has currently existed before in previously deployed systems. With the power of smartphones and the flexibility of the Android operating system, FIST can enable a much better level of collection at the forward edge of the operating environment. From the initial testing in Monterey, California, to data collection in Jakarta, Indonesia, to the maritime integration during CARAT Thailand, FIST has continued to demonstrate flexibility and resiliency in every environment. As the current development cycle progresses, future tests will be necessary to fully validate, vet, and analyze the system to maximize its effectiveness and usefulness for the end user, and FIST system tests during future workshops and exercises will serve as valuable testing grounds for system development.

FIST fundamentally changes the way we collect, process, analyze, aggregate, display and disseminate data in a variety of environments by leveraging the power of smartphones for field-based data collection and fused situational awareness. By providing an easy-to-use, inexpensive hand-held solution for achieving communications interoperability and a common operating picture of the physical and human terrain, FIST enables both on-the-ground field collectors and decision makers to share a common understanding of the operating environment. FIST truly is a unique system that has the ability to expand beyond its current aims and objectives and realize the goal of improving data collection, analysis, and finally knowledge for a variety of environments for a variety of people.

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